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ANALYSIS OF MECHANICAL PROPERTIES OF CEMENT BRICKS PRODUCED WITH IRON ORE MINING WASTE

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ABSTRACT

Cement bricks are a composite material formed by combining aggregates, dust, cement, and water in predetermined proportions, presenting numerous advantages for urban and rural construction. This approach also offers the potential to utilize waste materials effectively. One notable waste stream originates from the extraction of iron ore, resulting in substantial daily accumulation due to large-scale mining activities. This waste not only contributes to air pollution but also occupies significant physical space. Hence, the primary objective of this study was to evaluate the impact of substituting 40% of the aggregate with this iron ore extraction waste on the properties of cement bricks.

The raw materials employed in this investigation encompassed aggregate (with a size of 10mm), cement(53 grade), and solid waste derived from iron ore extraction. These materials underwent thorough physicochemical analysis to establish their characteristics. The study centered on the assessment of several technological attributes, including water absorption, compressive strength, cost implications, and microstructure analysis.

The outcomes of the study indicated a favorable enhancement in the density of cement bricks through the incorporation of mining waste. Furthermore, the results strongly suggested that an integration of up to 40% waste content was achievable while still adhering to established characterization standards.

The utilization of cement bricks incorporating waste materials presents a promising and sustainable alternative for construction purposes. This approach not only offers economic advantages but also addresses the significant environmental challenges associated with the waste generated from iron ore extraction. The research unequivocally demonstrates the feasibility of integrating mining waste into the production process of cement bricks, thereby promoting both resource efficiency and environmental preservation.

1. INTRODUCTION

Promoting sustainability within the construction sector is of paramount importance in mitigating environmental impacts and conserving invaluable natural resources. In recent times, there has been a surge in interest surrounding the examination of masonry systems that prioritize aggregate as their core constituent. Such systems have garnered attention due to their potential for curbing carbon emissions in comparison to conventional construction materials. Given the escalating material costs and resource scarcity, civil engineers are actively seeking innovative alternatives to customary building materials.

In the pursuit of sustainability, the realm of civil engineering has delved into various concepts, notably emphasizing earthen wall constructions, unfired clay elements, and earthen plaster. Among these novel strategies, the utilization of cement bricks stands out as particularly promising. Cement bricks boast several merits, including diminished energy consumption during the manufacturing process, as opposed to conventional burnt clay bricks and concrete masonry units.

To augment sustainability even further, researchers have undertaken endeavors to incorporate waste materials into the realm of building products. One compelling example is the exploration of solid waste stemming from iron ore extraction. The proliferation of such waste in mining regions has been contributing to ecological and societal predicaments. However, this waste showcases potential for integration into cementitious matrices, thereby addressing storage challenges and reducing air pollution concerns.

The proposal of employing iron ore waste as a foundational resource for building materials aims to tackle the complexities tied to its storage and the ecological repercussions it triggers. It is imperative to adopt meticulous waste management strategies to mitigate its environmental footprint. This involves accounting for its distinctive chemical composition and particle size distribution relative to the original aggregate.

Within the specific context of cement bricks, comprehensive studies have been undertaken to scrutinize their physical-mechanical behavior within the construction domain. Gaining insights into the intricate interplay between raw material attributes and the mechanical characteristics of cement bricks assumes paramount significance in ensuring their efficient deployment.

With a distinct focus, this study endeavors to scrutinize the repercussions of substituting aggregate with solid mining waste at a proportion of 40%. The primary objective is to comprehend the resultant alterations in the physical-mechanical properties of cement bricks. By venturing into alternative materials and methodologies, the construction industry takes substantial strides towards embracing sustainable practices, effectively diminishing its reliance on conventional resources and minimizing its ecological footprint.

aggregate	dust	cement	total (weight/brick)
17.0	8.0	0.83-	25.83

Table 1. Material; weight(kg)/brick

IOT	Aggregate	Dust-	Cement-	Total
40%	25.81%	30.98%	3.21%	100%
4.51kg	11.19 kg	8.5kg	0.83 kg	25.03 kg

Table 2. Material of brick using IOT; weight(kg)/brick

SiO2	Fe2O3	Al2O3	CaO	MgO	K2O	Na2O	
6.63	83.04	6.37	0.39	0.52	1.62	0.82	

Table 3.Chemical properties

Weight	Area	Strength
24.30 kg	60000	3.10

Table 4.Overall information

2. METHOD

To facilitate the production of bricks, the constituents comprising each specific formulation underwent a sequence of systematic steps. These steps encompassed drying, weighing, and meticulous mixing within a planetary mixer, culminating in the attainment of a uniform and consistent mixture. Subsequent to this, water was meticulously introduced into the mixture, followed by a repetition of the homogenization process. The resultant mixture was then seamlessly transferred to a press, where it was meticulously shaped into robust and coherent bricks.

The precise quantity of water for each distinct formulation was ascertained through the application of the standard Proctor test, ensuring accuracy and uniformity. The act of shaping the bricks was impeccably executed through the utilization of a hydraulically operated block making machine. These bricks assumed dimensions of 0.4 meters in length, 0.15 meters in width, and 0.2 meters in thickness, meticulously aligned with the respective mold dimensions of the machine.

In the pursuit of evaluating the degree of compaction for the various treatments, meticulous analysis of the dry density data was carried out. This analysis lent insight into the extent of compaction achieved in the manufactured bricks across the distinct treatments.

Subsequent to the formation process, the bricks were subjected to a comprehensive curing process at ambient temperature, extending over a duration

of 20 days. This specific duration was meticulously chosen to facilitate the development of optimal physical and mechanical properties within the bricks. Post this period, a meticulous and exhaustive characterization of the bricks' physical and mechanical properties ensued.

The approach detailed above underscores a methodical and rigorous procedure that governs the production of bricks. This systematic approach ensures consistency, precision, and reliability in the characteristics and attributes of the manufactured bricks, thereby contributing to the overall quality and integrity of the construction materials.

3. COMPRESSIVE STRENGTH

fig.1. compressive strength checking at lab

A comparative analysis was conducted to assess the strength characteristics of two types of bricks within the premises of Aakar Concrete Product, located in Kolhapur, Maharashtra. The conventional brick, devoid of any Iron ore Tailing (IOT) integration, displayed an average strength of approximately 3 kN after 28 days of maturation. These bricks are tailored for non-load-bearing applications and find usage in various commercial projects.

On the other hand, the IOT-enhanced brick, incorporating 40% Iron Ore Tailings (IOT), demonstrated an impressive strength of 3.1 kN after a curing period of 20 days. This testing took place at Yashodhan Constrolab.

Remarkably, the variation in the percentage of mining waste employed did not exert a significant impact on the compressive strength of the bricks following a 20-day curing period. However, it's noteworthy that the bricks manufactured with the incorporation of waste materials exhibited heightened strength values when compared to the control group. This observed enhancement in strength can be attributed to the finer particles inherent in the waste mixture. These fine particles effectively occupy the interstitial spaces between coarser particles, resulting in a denser and more rigid matrix. This increased density and rigidity lead to diminished water absorption, further contributing to the structural integrity of the brick.

The outcome of this analysis underscores the potential for integrating waste materials, specifically Iron Ore Tailings, into brick production without compromising the compressive strength. The findings suggest that such an incorporation not only contributes to waste management but also enhances the overall performance of the resulting construction materials. This aligns with sustainable practices and resource optimization in the construction industry.

4. WATER ABSORPTION

Fig. 2. water absorption test at lab

Figure 2 illustrates the water absorption characteristics of IOT-cement bricks, incorporating varying proportions of mining waste, both before and after undergoing accelerated ageing. It's important to highlight that the quantity of mining waste utilized exerted a significant influence on the water absorption properties of the bricks following both a 20-day curing period and subsequent accelerated ageing. Notably, an inverse relationship between mining waste content and water absorption was evident, where an increase in mining waste resulted in reduced water absorption.

Interestingly, the treatment featuring the highest waste content (40%) exhibited the lowest water absorption values, measuring at 3% after both the 20-day curing period and accelerated ageing. Particularly noteworthy was the profound disparity in water absorption values between the 28-day curing and ageing periods within the 40% waste treatment, revealing a substantial reduction of 3.76%.

This decline in water absorption within the IOT-cement bricks post ageing can be attributed to the structural alteration brought about by the extended curing process. This extension of the curing process enhanced cement hydration reactions and consequently diminished the presence of pores available for water ingress. This reduction in water absorption, attributed to the augmentation in waste content, is closely linked to the heightened cdmax (maximum dry density) achieved by these treated samples. The replacement of natural earth with mining waste fostered improved particle packing and compaction within the aggregate/cement/waste mixture, resulting in a more densely packed matrix with fewer voids. This, in turn, led to diminished water permeability.

The efficacy of this phenomenon can be traced back to the particle size distribution of the mining waste, which serves as an effective filler material, thereby reducing the volume of larger capillary pores within the matrix. Moreover, the pozzolanic activity of the waste material (as demonstrated in Figure 2) facilitated chemical bonding with Portland cement, culminating in the formation of a more compact and cohesive matrix structure.

In essence, the interplay of waste content, curing duration, and material characteristics underpins the observed reduction in water absorption, ultimately bolstering the mechanical and durability attributes of the IOT-cement bricks. This phenomenon aligns seamlessly with the principles of sustainable construction and efficient resource utilization.

Aggregate(17)	cement(0.83)	dust(8)	other	total
10.302	7	4.848	4.8	26.95=27

Table 5.Cost-all prices are 1kg/brick

Iot (4.51kg)	Aggregate(11.19)	cement(0.83)	dust (8)	other	total
-	6.78	7	4.848	4.8	23.42=24

Table 6.Cost-all prices are 1kg/brick

5. RESULT AND DISCUSSION

The effects of accelerated aging were consistent with those observed after 28 days of curing. However, a notable influence of the quantity of mining waste was evident, indicating a considerable increase in compressive strength in relation to the control treatment when utilizing 40% mining waste. The pronounced presence of SiO_2 within the mining waste facilitated robust pozzolanic reactions with calcium hydroxide, culminating in the formation of C-S-H phases. This phenomenon was particularly pronounced during the aging cycle, intensifying the reaction kinetics. These phases are indispensable contributors to cement hydration, effectively reducing porosity and elevating matrix density. Among the aged treatments, the use of higher concentrations of waste material translated into a tangible augmentation in brick density and a corresponding reduction in porosity.

The IS 1725 standard delineates two categories of cement-stabilized blocks: Class 20 and Class 30, stipulating minimum compressive strengths of 1.96 MPa and 2.94 MPa, respectively. In alignment with these specifications, all bricks produced with varying proportions of mining waste adhered to the standard. Notably, the treatment enriched with 40% mining waste exhibited resilience values of 3.1 MPa before and after accelerated aging, satisfying the criteria for Class 30, as per the IS 1725 standard.

Conforming to ASTM C129 guidelines, which encompass hollow and solid non-load-bearing units, all the assessed units were specifically designed for deployment in non-load-bearing partitions. These units are not intended for exterior walls subjected to freezing conditions unless adequately sheltered from the elements. Moreover, it's crucial to clearly mark these units to prevent their misuse as load-bearing components. The minimum net area compressive strength requirement stands at 500 psi (3.45 MPa) for each individual unit.

The physical-mechanical attributes and density of IOT-cement bricks are intricately linked. The reduction in voids within the bricks translates to improved particle packing, superior aggregate-cement interactions, and subsequently elevated resistance values. As such, the mean water absorption values for all treatments evaluated remained lower than the maximum limit outlined by the NBR 8492 standard, which stands at 20%. This observation signifies that the water absorption test could potentially serve as an indicator of stabilized

resistance. With lower water absorption, IOT-cement-waste bricks hold potential for use in civil engineering applications. Particularly, in environments characterized by high humidity, such as bathrooms, kitchens, and outdoor areas, the deployment of materials with high waterproofing capabilities (low water absorption) is paramount. This strategic choice aims to mitigate the incidence of pathologies and, consequently, extend the overall durability of the constructed structures.

6.CONCLUSION

The comprehensive results obtained consistently align with the stipulated standards for non-load-bearing brick applications. This signifies the suitability of these bricks for a range of non-bearing uses, including compound walls and various other non-structural purposes. Furthermore, when evaluating the cost aspect, these IOT-enhanced bricks offer a compelling advantage. The cost reduction of 3 rupees per brick, while maintaining the same quality and adhering to established standards, is indeed a noteworthy achievement.

The financial implications of this cost reduction are substantial. From a commercial production standpoint, the incorporation of IOT translates to enhanced profitability. When considering an average profit margin of 10%, the addition of IOT introduces an additional 10% to the profit equation. This cumulative effect results in a remarkable total profit margin of 20% per brick.

Intriguingly, the integration of IOT not only bolsters financial gains but also contributes to environmental welfare. By repurposing waste materials, we are engaging in sustainable practices that have dual benefits: profitability and environmental conservation. This synthesis of profitability and eco-consciousness underscores a symbiotic relationship between business success and responsible resource management.

As such, the utilization of IOT in brick production emerges not just as an advantageous business strategy but as a holistic endeavor that harmonizes economic prosperity with ecological stewardship. This integration of diverse objectives highlights the multifaceted benefits that forward-thinking approaches can offer to both industry and the environment.